

APPENDIX B

Vendor Claims

INTRODUCTION

This report is written to summarize the activities undertaken during the sediment melter demonstration project. This demonstration was Phase 3 of a multi-phase feasibility study. The first two phases of the feasibility study determined that the minerals contained in dredged sediments could form a stable glass, and that the variability of mineral concentrations along the lower Fox River appeared to be within acceptable ranges.

During a demonstration dredging project, the Wisconsin DNR containerized approximately 60 tons of de-watered, contaminated river sediment. The DNR contracted with Minergy for the design, construction, and operation of a pilot melter, to melt the sediment into a glass aggregate.

The melter evaluation was performed at Minergy's GlassPack Test Center in Winneconne, Wisconsin. A demonstration-scale melter was constructed, with operation of the melter from May to August, 2001. The pilot program was designed to confirm that the technology can destroy PCB contamination, stabilize trace metals, and convert the mineral content of river sediment into an inert, marketable construction material.

Under SITE program, the fate of PCBs and other compounds within the river sediment were monitored during the processing and melting of the river sediment.



SYSTEM DESIGN

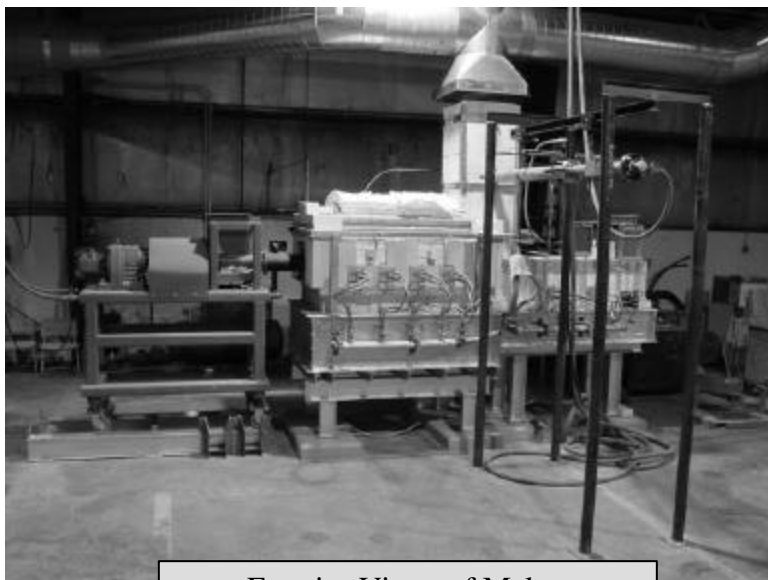
Phase III of the project included construction and operation of the sediment demonstration melter, and subjected to the monitoring by U.S. EPA SITE program. This phase was performed at Minergy's GlassPack Test Center in Winneconne, Wisconsin.

The pilot melter is designed to simulate a full-scale production melter for the generation of glass aggregate from sediments. In order to adequately produce a model, some assumptions have been made with regard to the full-scale melter in accordance with typical glass operating practices. The pilot melter is scaled down from the full-scale melter and has been designed to operate in a manner which would suggest design features for most major elements of the full scale melter.

Pilot Melter Characteristics

Aspect Ratio	2:1
Area	10 sq ft.
Melting Rate	5.4 ft. ² /ton
Dwell Time	6 hrs.
Gas Usage	1.7 MM Btu/hr.
Oxygen Usage	35 ccfh
MM Btu/Ton	20.9 mmbtu/ton
Output	2 tons/day

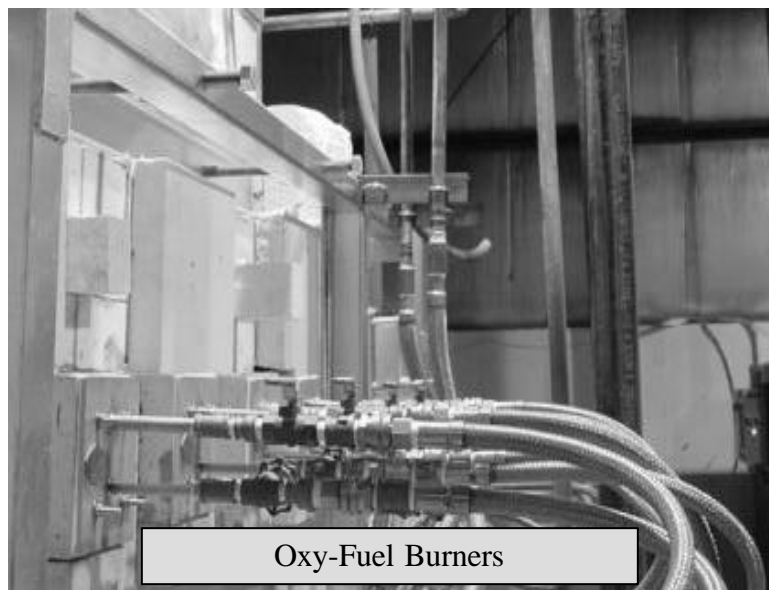
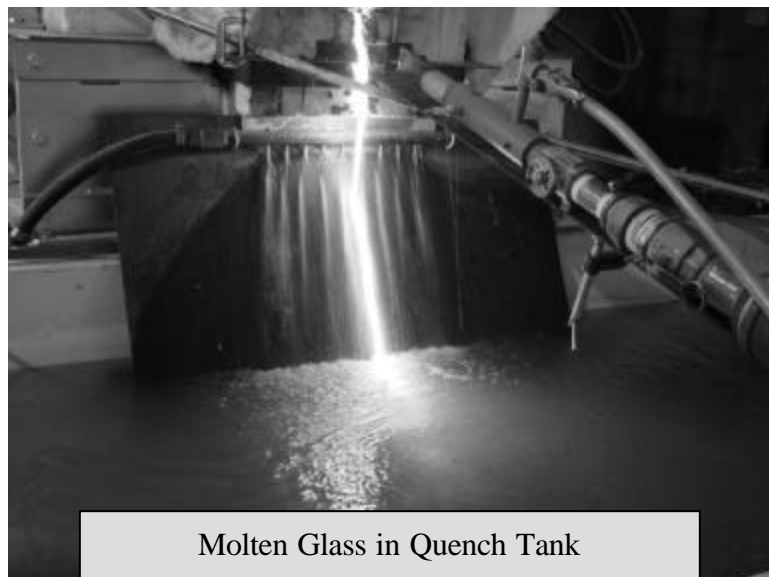
Several features were incorporated to the standard melter design in order to best suit this application. These modifications include:



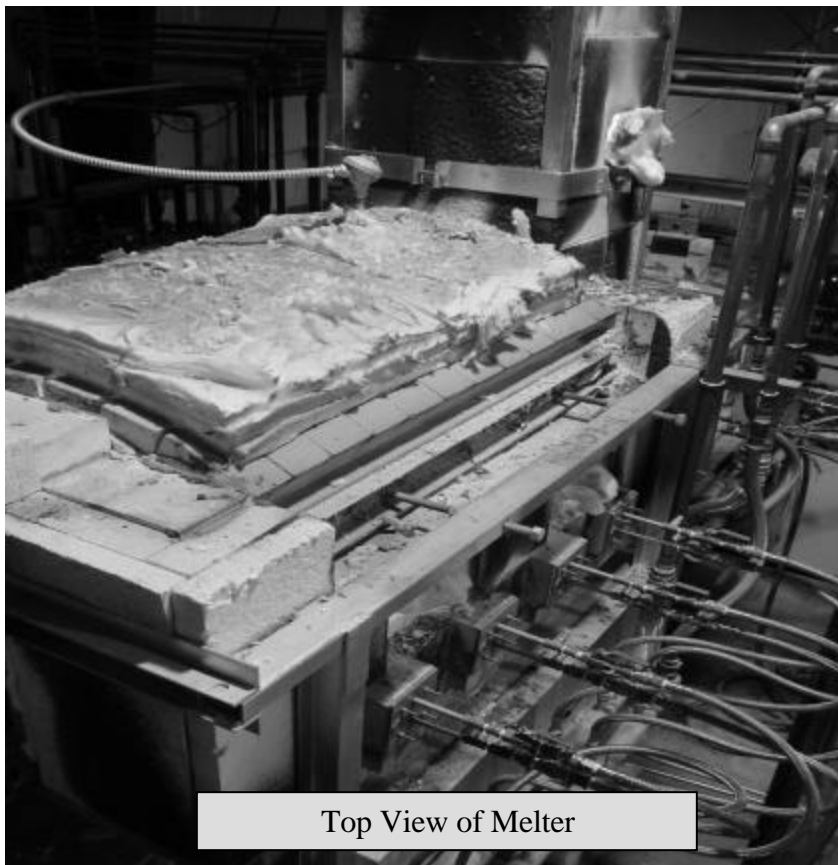
Exterior Views of Melter



- The use of a water quench system to quickly harden the molten glass and increase the inert characteristics of the final product. Glass melters typically use annealing or other slow-cooling products to enhance glass clarity and other product qualities. These product features are not significant in the manufacture of glass aggregate because its final use is as a construction product where glass clarity is not necessary. Molten material is drained from the end of the melter into the water-filled quench tank. An inclined $\frac{1}{4}$ -inch steel plate, cooled by a constant water stream, directs falling liquid aggregate into the quench tank.
- An inclined screw conveyor removes hardened aggregate from the quench tank. The conveyor's hopper is submerged in the quench tank. The auger moves the aggregate out of the quench tank into barrels.
- The melter has eight Split-Stream oxy-fuel burners to approximate the burners that would be used in a full-scale melter. The melter is oxy-fuel fired to utilize the B.A.C.T. for NO_x emissions and reduced particulate.



- The pilot melter is 10 square feet with a 2:1 aspect ratio. The materials selected are typical for soda-lime glass operations in an oxy-fuel environment. Six inches of extra sidewall has been added to the height to accommodate organics contained in the sediment feedstock. The glass quality is adequate with 6 hours of dwell time, so it runs a shallow glass level.
- The flue is located in the front of the melter, which is not the traditional location for oxy-fuel furnaces. This is done so that any fine particulate that becomes entrapped into the exhaust gases will have the maximum time in the furnace to allow these particulates to be melted, or minimized.
- The melter was designed and built under a contract with Frazier-Simplex of Washington, Pennsylvania.



- The pilot melter is controlled by control loops to the melter and forehearth. The control loops use thermocouple signals to maintain a constant temperature by automatically adjusting the gas and oxygen for each zone. The control panel contains two single loop controllers, two digital gas flow meters, two digital oxygen flow meters, six digital temperature meters, status lights for the main fuel train, E-stop, alarm horn, and alarm silence push button.



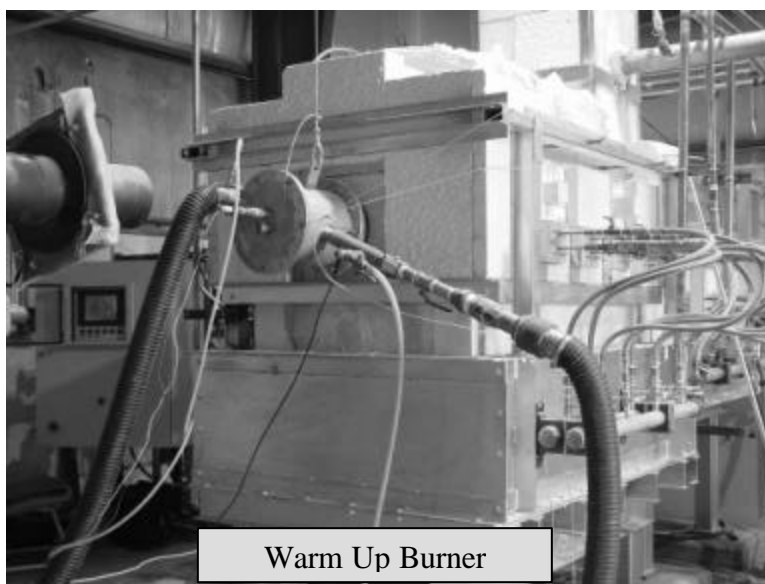
Control Panel

- Both the gas and oxygen skids have essentially the same safety system. A strainer is utilized prior to a pressure regulator. A high/low pressure switch is tied to the double block automatic shut-off valves. A differential pressure switch is used to determine flow through the system. This is a safeguard against injecting raw natural gas or oxygen into the furnace. If flow is lost on either natural gas or oxygen, the skid shuts down that zone. Each zone is then automatically controlled for gas and oxygen flows via a signal from the mass flow meter to a control loop back to an automatic valve.

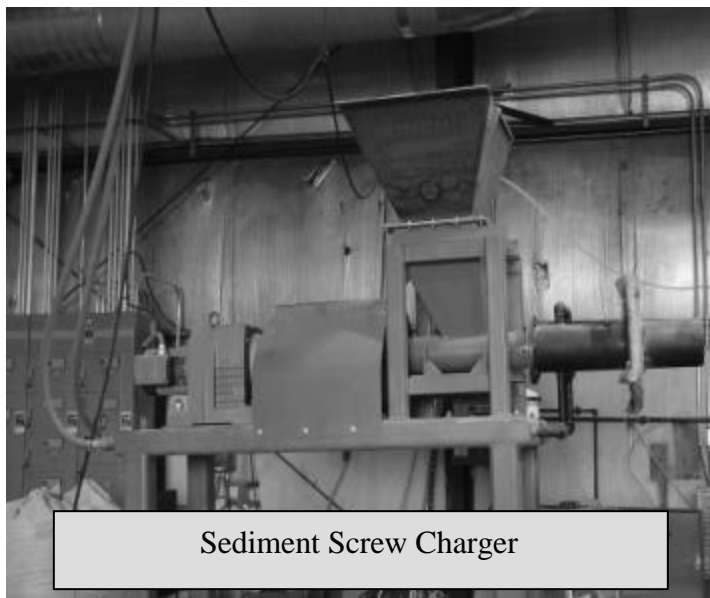


Oxy-Fuel Control System

- Refractory selection has been developed for this pilot melter based on the heat flow analyses for each construction type. These are used to insure that none of the materials is placed in temperatures beyond their capability and to determine the total heat loss of the entire system.
- The use of refractory selected by evaluating the abrasive qualities of the molten sediment. Glass products vary according to the chemical makeup of the feedstock. After the June run, an inspection of the inside of the forehearth verified that the refractory material at the glass line was seeing significant wear. The melter was relined with a higher grade refractory in place of the mullite originally installed in the melter for the August run.
- Startup of the melter is performed gradually over 36-48 hours. A separate, dedicated warmup burner is used to raise the temperature of the melter to approximately 1,400 degrees F. After this temperature, the main burners are used to reach final temperature target of 2,900 degrees F.
- The melter uses a “shallow” glass line. Glass melters typically have deeper pools of glass inside the melter, taking advantage of the low opacity of the glass being produced. Molten sediments are quite opaque, thus reducing energy transfer by radiation.



- Sediment is fed in on one end of the melter through a water-cooled screw charger. The charger is a standard screw batch charger that has been used all over the world for charging batch in glass furnaces. The screw charger was chosen due to the ability to tightly seal the charging hopper to the charger and the charger to the furnace. This minimizes dusting of the raw material feedstock. The charger is similar in size to that which would be used in a full-scale unit. It has been retrofitted with a small screw barrel and flights for the pilot melter. This charger can be reused for a full-scale melter by modifying the barrel and flights. A variable-speed drive allows control of the feed rate.
- Negative pressure and air filtration is placed on the feed hopper during charging operations to control dust.
- The melter design capacity is 2 tons per day or 170 pounds of river sediment per hour. The sediment bags weighed approximately 50 gross pounds, so the feed rate was between four and five bags per hour.



Sediment Screw Charger



Sediment Feed



Air Filtration on Sediment Hopper



Batch Bags of Dried Sediment



Extraction Probe

- An extraction probe is used to cool the hot gas from the melter exhaust at a controlled rate. The rate of cooling would be equivalent to the heat recovery systems installed on a full scale melter system.

The section of the probe which is inserted into the melter is contained in a water-cooled jacket, and is hung from a rail that allows it to be inserted into the stack for testing, then removed when testing is not taking place. A cleanout port is placed on the back end of the probe, and a brush and rod are used to manually clean out particulate buildup within the probe.



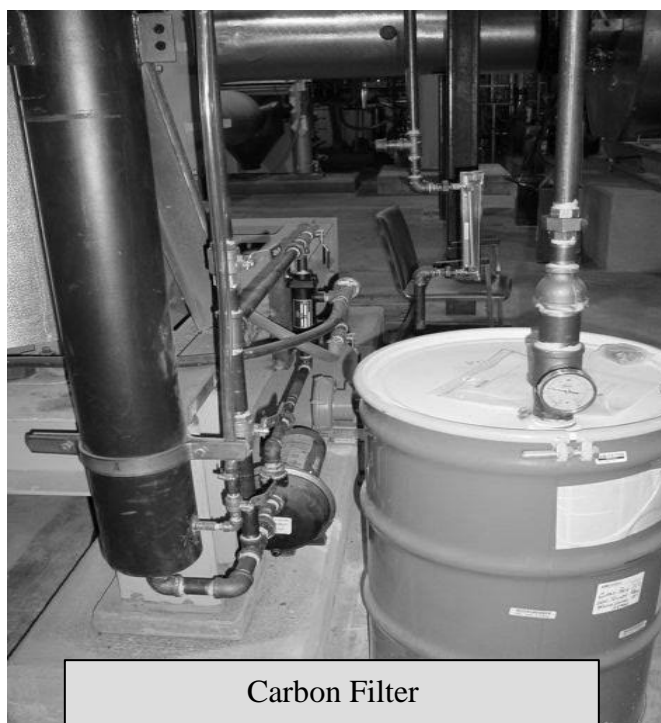
Packed Tower Condenser

- Sampling ports are located before the condenser and after the carbon filter, to allow connection of air testing equipment.



US EPA Testing

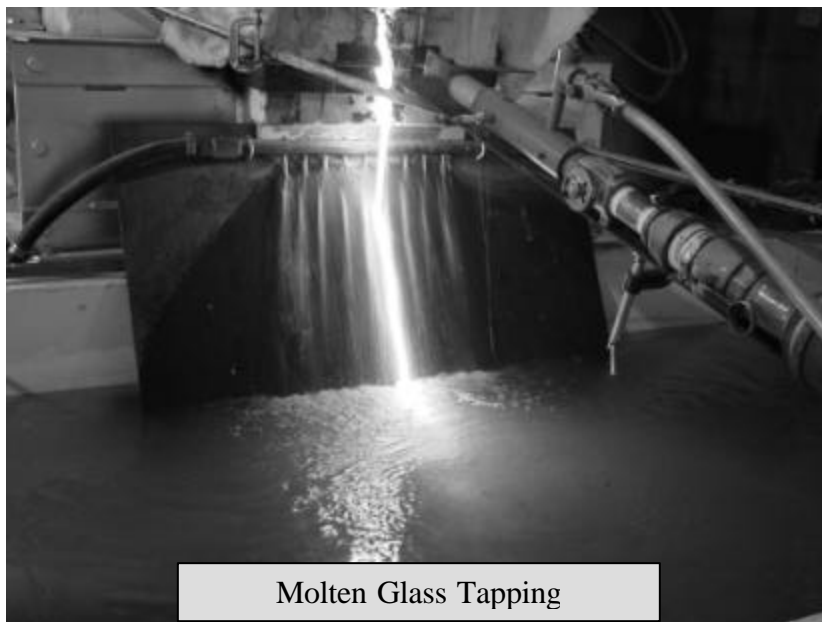
- Piping connects the extraction probe to a contact packed tower condenser. An induced draft fan pulls the exhaust gases through the tower condenser, and then through a carbon barrel, before discharging the air stream out of doors.



Carbon Filter

CONCLUSIONS

- The demonstration project determined that river sediment melts easily at high temperature into a hard, angular aggregate. The melter worked well with this type of feedstock, and the end product appeared consistent and marketable. When river sediment was being fed into the melter, temperatures within the melter were maintained between 2600 and 2900 degrees F.
- The demonstration clearly showed that sediment will successfully create a quality glass aggregate material using a glass furnace. The properties of the glass aggregate product were quite positive. The aggregate was very consistent, producing a hard, dark, granular material.



Conclusions Drawn From Results

- 1) PCB
 - a) Met the "six nines" criterion for stack basis Destruction Removal Efficiency
 - b) Treatment efficiency was 99.999488%
- 2) Dioxin
 - a) No 2,3,7,8 TCDD was detected in the stack either before or after the carbon filter
 - b) Greater than 99.9% removal of dioxins/furans both before and after the carbon filter
- 3) Mercury
 - a) No mercury was detected after the carbon filter
 - b) Removal efficiency was greater than 99.9%
- 4) Glass Aggregate
 - a) Leach test showed no-detect or no significant levels of any test parameter
 - b) PCB mass was less than that found in U.S. food supply and were not bioavailable



INTERPRETATION OF PROJECT RESULTS

1.0 Six Nines Destruction Removal Efficiency (DRE).

- 1.1 Background. Section 40 CFR 761.70 of federal environmental regulations sets forth requirements for processing PCB waste in a commercial facility. The requirement states that the mass air emissions shall be no greater than 0.001 gram PCB out per kilogram PCB in. Calculating the corresponding DRE by substituting 1000 grams for 1 kilogram, the "six nines" are derived:

$$\text{DRE} = (W_{\text{in}} - W_{\text{out}}) / W_{\text{in}} \times 100\%$$

$$\text{DRE} = (1000.0 - 0.001) / 1000.0 \times 100\%$$

$$\text{DRE} = 99.9999\%$$

The six nines are attributable to the six digits behind the decimal point in the decimal equivalent of a percentage (ie, 0.999999 = 99.9999%).

- 1.2 Calculation of the GFT's Six Nines DRE. The GFT demonstration met the Six Nines DRE. According to the EPA SITE report, the PCB concentrations were:

Sediment Entering Melter	27.8	parts per million
Flue Gas Exiting Melter	0.00000351	parts per million

Using the DRE formula,

$$\text{DRE} = (W_{\text{in}} - W_{\text{out}}) / W_{\text{in}} \times 100\%$$

$$\text{DRE} = (27.8 - 0.00000351) / 27.8 \times 100\%$$

$$\text{DRE} = 99.999987\%$$

As can be seen, the GFT achieved *greater* than the six nines reduction.

- 1.3 Discussion on ITER Treatment Efficiency. The U.S. EPA SITE Innovative Technology Evaluation Report calculates a Treatment Efficiency (TE) of the demonstration project of 99.9995%. It should be noted that the TE is not the same as the DRE specified in 40 CFR 761.70. Instead, the TE was calculated by summing the PCB concentrations of the flue gas, the quench water, and the glass aggregate.

2.0 Full Scale Implementation Expected To Be Even Better.

- 2.1 Quench Water. In a commercial facility, the aggregate tank quench water will be treated prior to discharge to the wastewater treatment plant. It is highly probable that the source of residual concentrations was small particles of glass aggregate suspended in the quench water. The combination of pre-treatment and wastewater treatment will be very effective in removing the suspended Glass Aggregate from the quench water. Therefore we would expect quench water PCB concentrations to be even lower in a full-scale system
- 2.2 Dust in Exhaust Gas. As indicated in the EPA report, the sample probe used for exhaust gas measurement was subject to accumulations of sediment dust. In a full-scale facility, a particulate control device would be used. No control device was used in the demonstration due to cost constraints. Devices of this sort are commercially available and are highly efficient at removal of dust. The collected dust would be re-directed back into the melter for treatment. Therefore we would expect the exhaust gas PCB concentrations to be even lower in a full-scale installation.
- 2.3 Residence Time. The melter used in the demonstration project had a 2 second gaseous residence time. The design of a full scale melter would allow for a gaseous residence time of 16 seconds. This longer residence time would be expected to significantly increase the destruction efficiency over that which was seen in the demonstration. Therefore we would expect the exhaust gas PCB concentrations to be even lower in a full-scale installation.

3.0 Glass Aggregate Product Is Very Inert.

- 3.1 Non-Leaching. As indicated in the EPA report, the PCBs in the Glass Aggregate were non-leachable for all tests, including those done on Glass Aggregate that had been finely ground. This is because the PCBs have either been destroyed or have been permanently stabilized in the ceramic matrix of the glass.

- 3.2 Not Bioavailable. As indicated in the attached Risk Perspective Toxicologist Report (issued as part of this section of Vendor Claims), PCBs in the Glass Aggregate are non-bioavailable and do not represent a health risk. The Toxicologist Report also shows that the PCBs detected in the Glass Aggregate are below background concentrations and are less than most foodstuffs in the American diet.

- 3.3 Exemption from Wisconsin DNR. The Wisconsin Department of Natural Resources has reviewed the EPA SITE report and the resultant data on the inertness of the Glass Aggregate. They have concluded that "the beneficial use of processed river sediment, as proposed, and in accordance with the conditions of this approval, will not result in environmental pollution." The WDNR has provided an exemption from all Wisconsin solid waste regulations for the Glass Aggregate.

Minergy Glass Aggregate A Risk Perspective

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A. INTRODUCTION

In 2002-3, U.S. EPA conducted an innovative technology evaluation of Minergy Corporation's Glass Furnace Technology (Feb. 2003). This technology is a proposed ex situ remediation technology that has been designed to treat river/lake sediments contaminated with inorganic and/or organic materials. The product from the process is a black glass aggregate, comprised of particles the size of coarse sand.

As part of this U.S. EPA study, analytical testing was conducted on both the process input material (sediment) and its output product (aggregate). These data from the study indicated that there was >99.99% PCB and PCDD/PCDF¹ destruction, and that all chemical residuals that were remaining in the aggregate were non-leachable. Among other analytes, residual PCBs and PCDD/PCDF were identified in the glass aggregate. To put the residual concentrations of these specific analytes in the glass aggregate in perspective, Minergy Corporation contracted with STS Consultants, Ltd. to conduct a risk analysis on the material. Also addressed in this study was the residual PCB concentration detected in the process quench water.

The approach taken in this data interpretation study was to compare the residual PCB and PCDD/PCDF concentrations in the glass aggregate and PCB concentrations in the quench water to:

- typical background levels of these substances in the environment,
- risk-based remediation goals used in state/federal Superfund/RCRA programs, and/or
- other state guideline/rule concentrations of these chemicals.

B. GLASS AGGREGATE

Analytical Data

Shown in Table 1 are the residual PCDD/PCDF and PCB concentrations in the glass aggregate, as obtained from Table 4-5 of U.S. EPA's draft Innovative Technology Evaluation Report (2003).

¹ PCDD/PCDF = polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans.

PCDD/PCDF

As is shown in this table, the range of residual PCDD/PCDF (in total TCDD equivalents) in the aggregate was 0.1123 - 0.1565 pg/g, assuming each congener is present at its detection limit. The average concentration from the four samples using this conservative approach is 0.1376 pg/g. If the non-detected analytes were considered to not be present in the material, then the PCDD/PCDF concentration would be zero in three samples and 0.1565 pg/g in one sample. Averaging these values leads to a mean value of 0.0391 pg/g.

PCBs

Also shown in Table 1 are the residual PCB results on the glass aggregate. As is evident, there was a wide range of total PCB concentration within the samples. The range reported in the study was <26-1240 pg/g. The average total PCB concentration of the six samples (again conservatively assuming that the non-detected value was present at this detection limit) was calculated to be 414 pg/g.

Risk Analysis

To put the residual aggregate PCB and PCDD/PCDF data into perspective and to provide a qualitative risk evaluation of the glass aggregate, STS performed a comparison of the analytical data in Table 1 to soil background concentrations of these compound groups, to risk-based soil cleanup goals, and to background concentrations of these compounds in various foodstuffs. Also, the PCB concentration was compared to biosolids concentrations acceptable for landspreading in Wisconsin.

The foodstuff PCDD/PCDF concentrations listed in Table 1 were taken from Schecter et al. (1997). These investigators measured PCDD/PCDF in pooled food samples that were collected in 1995 at supermarkets across the United States.

PCDD/PCDF

As can be seen in Table 2, the glass aggregate PCDD/PCDF concentration is considerably less than typical soil background levels of these compounds and considerably less than typical risk-based cleanup goals for soils, calculated to be protective of human health. In fact, the glass concentration of PCDD/PCDF is less than most foodstuffs in the U.S. diet. Also, it is important to note that since these residual compounds were found to not be leachable from the glass aggregate, they will not be bioavailable, i.e., in a form that could be absorbed into the body, even if an individual such as a young child were to incidentally ingest some of this material. They also would not be bioavailable to fish and other aquatic life if the material were to be reintroduced back into a surface water system, i.e., as a sediment capping material.

Based on the above comparisons and analysis, it can be concluded that the residual PCDD/PCDF in the glass aggregate are at very low levels and will not present a significant risk to human health or the environment.

PCBs

As can be seen in Table 2, the glass aggregate PCB concentration is considerably less than typical risk-based cleanup goals for soils, calculated to be protective of human health, and less than Wisconsin DNR's soil criterion to be protective of wildlife. The residual PCB concentrations are also much less than typical biosolids concentrations that WDNR has approved for landspreading. The glass aggregate residual PCB concentration is less than or in the range of many of our foodstuffs in the U.S. diet. Also, as with the PCDD/PCDF, the residual PCBs in this glass aggregate were not found to be leachable.

Based on the above comparisons and analysis, it can be concluded that the residual PCB in the glass aggregate are at low levels and will not present a significant risk to human health and the environment.

C. QUENCH WATER

Analytical Data

Shown in Table 3 are the concentration data for PCB in the process stream quench water. These data were obtained from Table 4-7 of U.S. EPA's draft Innovative Technology Evaluation Report (2003).

As is evident, only two PCB congeners were found. The total PCB content in the water varied from <0.500 ng/L to 1.09 ng/L. Assuming that the non-detected total PCB values were present at the reported detection limits, the average PCB concentration from these six quench water samples was 0.615 ng/L. If the non-detected values were assumed to not be present in these samples, then the average concentration is 0.365 ng/L.

Risk Analysis

To put these residual PCB data into perspective, a comparison was made to the State of Wisconsin's Groundwater Standards. These standards have been developed to be protective of human health, assuming an individual ingests groundwater daily (as drinking water) throughout their lives. The WDNR's enforcement standard for PCBs is 30 ng/L; their Preventive Action Limit is 3 ng/L. It is therefore apparent that the residual PCB concentration in the process quench water, 0.365-0.615 ng/L is well below these safe drinking water exposure levels.

Since this process quench water would never ever be utilized as a drinking water source and will be treated prior to discharging to a sanitary sewer system (Minergy, personal communication), it can be concluded that the residual PCB in this water will not present a significant risk.

**Table 1: Glass Aggregate
Analytical Data (pg/g)^A**

A. PCDD/PCDF

<u>Congener</u>	<u>M-G-01</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.151	0.5	0.0755
1,2,3,7,8-PeCDF	<0.0684	0.05	0.0034
2,3,4,7,8-PeCDF	<0.0668	0.5	<u>0.0334</u>
		TOTAL	0.1123

<u>Congener</u>	<u>M-G-02</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	0.173(J)	0.5	0.0865
1,2,3,7,8-PeCDF	0.149(J)	0.05	0.0075
2,3,4,7,8-PeCDF	0.125(J)	0.5	<u>0.0625</u>
		TOTAL	0.1565

<u>Congener</u>	<u>M-G-03</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.165	0.5	0.0825
1,2,3,7,8-PeCDF	<0.0826	0.05	0.0041
2,3,4,7,8-PeCDF	<0.0806	0.5	<u>0.0403</u>
		TOTAL	0.1269

<u>Congener</u>	<u>M-G-04</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.189	0.5	0.0945
1,2,3,7,8-PeCDF	<0.111	0.05	0.0056
2,3,4,7,8-PeCDF	<0.109	0.5	<u>0.0545</u>
		TOTAL	0.1546

B. PCBs

<u>Sample</u>	<u>PCBs (total)</u>
M-G-01	790
M-G-02	<26
M-G-03	58
M-G-04	27
M-G-05	1240
M-G-06	345

^A Data taken from Table 4-5 (Draft ITER, Minergy Corporation, Feb. 2003)

^B Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. EPA, 1998.

Table 2: Comparative Data

A. PCDD/PCDF

	<u>Concentration (pg/g)</u>
Minergy's Glass Aggregate	0.04 - 0.14 ^A (0.11-0.16)
freshwater fish ^B	1.43
butter ^B	1.07
hot dog/bologna ^B	0.54
ocean fish ^B	0.47
cheese	0.40
beef ^B	0.38
eggs ^B	0.34
ice cream ^B	0.33
chicken ^B	0.32
pork ^B	0.32
milk ^B	0.12
vegetables, fruits, grains, legumes ^B	0.07
soil (background) ^C	5.00 (0-57)
soil (risk-based remediation goal for residential land use)	20.00-200.00

B. PCBs

Minergy's Glass Aggregate	414 ^A (<26-1240)
fresh fish ^D	7481
hot dog/bologna ^D	3527
butter ^D	3234
ocean fish ^D	1758
chicken ^D	1040
beef ^D	980
pork ^D	879
cheese	584
eggs ^D	212
vegetables, fruits, grains, legumes ^D	159
soil (risk-based remediation goal for residential land use)	120,000 - 1,200,000
soil (WDNR wildlife criteria)	1900
WI Proposed PCB landspreading rule (2002) biosolids	
• 89% municipalities	>50,000
• median concentration	150,000

^A Mean value

^B Taken from UDSA (2000) - www.mindfully.org/Food/Dioxins-Food-Chain-USDA2000.htm

^C www.nutrifor.com/dioxin_factsheet.htm

^D Schechter, A. et al. (1997) Chemosphere 5-7, 1437-47.

Table 3: Quench Water Analytical Data (ng/L)^A

<u>PCB Congener</u>	<u>Sample</u>					
	<u>M-QW-01</u>	<u>M-QW-02</u>	<u>M-QW-03</u>	<u>M-QW-04</u>	<u>M-QW-05</u>	<u>M-QW-06</u>
8-diCB	<0.500	0.513	<0.500	<0.500	<0.500	<0.500
18,(30)-TriCB	0.563	0.575	<0.500	0.539	<0.500	<0.500

^A Data taken from Table 4-7 (Draft ITER, Minergy Corporation, Feb. 2003)

